- cis-1,2-dichloroethene (14 ug/l, 24.0 ug/l)

The concentrations of trichloroethene in CJ-4S (7.1 ug/l and 16.8 ug/l) were reported by the laboratory to be in excess of the AGQS and the Method 1 groundwater standard for category NH GW-1 of 5 ug/l. In addition, one or more VOCs were reported by the laboratory in the bedrock monitoring wells ATC-2, CJ-3, and CJ-4D. These VOCs included:

ATC-2

- 1,1-dichloroethene (130 ug/l)
- 1,1-dichloroethane (324 ug/l)
- 1,1,1-trichloroethane (621 ug/l)
- benzene (1.6 ug/l)
- trichloroethene (12.6 ug/l)
- tetrachloroethene (5.5 ug/l)
- vinyl chloride (3.2 ug/l)
- MTBE (1.8 ug/l)

CJ-3

- 1,1-dichloroethane (3.8 ug/l, 5.4 ug/l, 21 ug/l, 23 ug/l)
- 1,1,1-trichloroethane (5.9 ug/l, 6.6 ug/l)
- chloroethane (8.6 ug/l and 9.5 ug/l)
- MTBE (4.8 ug/l, 5.3 ug/l, 6.2 ug/l, 6.5 ug/l)

CJ-4D

- 1,1-dichloroethene (2.9 ug/l)
- 1,1-dichloroethane (5.0 ug/l)
- 1,1,1-trichloroethane (9.4 ug/l)
- Trichloroethene (6.1 ug/l, 13.8 ug/l)

None of the VOCs in CJ-3 were reported in concentrations equal to or greater that established NHDES standards. However, six VOCs were reported in ATC-2 in concentrations equal to or greater than NHDES standards. Two VOCs, 1,1-dichloroethene and vinyl chloride, had concentrations in excess of both the AGQS/Method 1 groundwater standard for category NH GW-1 and the Method 1 groundwater standard for category NH GW-2. The concentrations of 1,1-dichloroethane, 1,1,1-trichloroethane, trichloroethene, and tetrachloroethene were reported in excess of the AGQS/Method 1 groundwater standard for category NH GW-1. Monitoring well CJ-4D had one VOC, trichloroethene, in a concentration greater than the AGQS/Method 1 groundwater standard for category NH GW-1.

Monitoring wells ATC-2 and CJ-3 were also reported to contain VOCs as TICs (Table 12). 1,1-Dichloro-1-fluoroethane and chlorodifluoromethane were detected in ATC-2, although the laboratory could not quantify or estimate the concentrations of these compounds. Trimethylsilanol was reported in CJ-3 at an estimated concentration of 4.3 ug/l. The NHDES has not established AGQS or Method 1 standards for these compounds.

Natural Attenuation Parameters

Table 13 summarizes the testing results for analytical parameters associated with natural attenuation characteristics.

Groundwater testing results reveal that of the seven natural attenuation parameters analyzed by the laboratory and for those that have established NHDES standards, the concentration of nitrate-nitrogen in overburden monitoring well ATC-4-2 (50 mg/l and 66.1 mg/l), and bedrock monitoring wells CJ-2 (11 mg/l) and CJ-3 (42 mg/l, 43 mg/l, and 66.1 mg/l) were reported in excess of the AGQS/Method 1 groundwater standard for category NH GW-1 of 10 mg/l.

<u>6.2.2.7 Quality Control Samples</u>

In addition to the laboratories' internal quality control program, Cushing & Jammallo's quality control program consisted of sample duplicates and trip blanks. During the June 14 and 15, 2000 sampling event, Cushing & Jammallo collected three duplicate samples for laboratory analyses. The sample labeled as Supply Well 3 DUP is a duplicate of Supply Well 3. Both of these samples were submitted to the laboratory for analysis of VOCs by EPA Method 8260B plus TICs, total chloride, nitrate-nitrogen, sulfate, ferrous iron, soluble manganese, total organic carbon, and methane. The sample labeled as CJ-3 DUP is a duplicate of CJ-3. Both of these samples were submitted to the laboratory for analysis of VOCs by EPA Method 8260B plus TICs, total chloride, nitrate-nitrogen, sulfate, ferrous iron, soluble manganese, total organic carbon, and methane. The sample labeled as Septic-Warehouse DUP is a duplicate of Septic-Warehouse. Both of these samples were submitted to the laboratory for analysis of VOCs by EPA Method 8260B plus TICs. In addition to the duplicate samples, two trip blanks supplied by the laboratory, were analyzed for VOCs by EPA Method 8260B plus TICs.

Quality control samples utilized during the July 2000 sampling event included one duplicate sample and two trip blanks. The sample labeled as CJ-3 DUP is a duplicate of CJ-3. The duplicate sample was analyzed for VOCs by EPA Method 8260B plus TICs only. The laboratory supplied two trip blanks that were analyzed for VOCs by EPA Method 8260B plus TICs.

The testing results of the duplicate samples are summarized in Tables 11 through 13 and the laboratory testing results are presented in Appendices I and J.

6.3 Sampling And Analysis Of Septic Systems

During the June 2000 sampling event, liquid samples were collected from each of the two sanitary septic systems that serve the Site. These samples were labeled as Septic-Oper, Septic-Warehouse, and Septic-Warehouse DUP. The sample labeled as Septic-Oper was collected from the septic system associated with the Operations Building. This system (septic tank, distribution box, and leaching field) is located beneath the lawn that is just southeast of the Operations Building (Figure 2). The samples labeled as Septic-Warehouse and Septic-Warehouse DUP were collected from the septic system associated with the Warehouse. This system (septic tank, distribution box, and leaching filed) is located beneath the paved parking area west of the Warehouse Building (Figure 2).

Initially, the intent of this portion of the sampling program was to collect samples from the septic tank associated with each subsurface disposal system. However, the septic tank to each system contained a large amount of solids. Therefore, liquid samples were collected beneath the manhole covers associated with the distribution boxes. Samples were collected in a dedicated polyethylene bailer that was lowered into the area of each distribution box. These samples were delivered to the laboratory for analysis of VOCs by EPA Method 8260B, including TICs. The samples were placed in containers supplied by the laboratory that had hydrochloric acid as a chemical preservative. For quality control purposes, one trip blank and one temperature blank were supplied by the laboratory. The samples were placed on ice and delivered to the laboratory for analysis. A chain-of-custody form was completed and included in the shipment. Laboratory testing results are summarized in Table 14 and presented in Appendix I.

The testing results revealed that toluene and 4-isopropyltoluene were reported in samples from each of the septic systems. The sample collected from the septic system associated with the Operations Building (Septic-Oper) reportedly contained 120 ug/l of toluene and 520 ug/l of 4-isopropyltoluene. The sample collected from the septic system associated with the Warehouse (Septic-Warehouse) reportedly contained 34 ug/l of toluene and 500 ug/l of 4-isopropyltoluene. A TIC known as d-limonene, with an estimated concentration of 62 ug/l was also identified in this sample. D-limonene is a naturally occurring terpene. Limonenes are derived from lemon, bergamot, caraway, orange, peppermint, spearmint and other oils and is used as or in flavorings, fragrances and perfumes, solvents, wetting agents, and in resin manufacture. This compound may be contained in routine cleaning agents that are used by JJA and subsequently flushed into the sanitary septic system. The sample duplicate (Septic-Warehouse DUP) reportedly contained 34 ug/l of toluene and 530 ug/l of 4-isopropyltoluene. No TICs were identified in the duplicate sample.

7.0 GEOLOGY AND HYDROGEOLOGY

7.1 Regional and Site Specific Geology

7.1.1 Surficial Geology

According to the mapping of the surficial geology of New Hampshire by Goldthwait, Goldthwait, and Goldthwait (1951), the area occupied by the Site consists of ground moraine glacial till of Pleistocene age.

Surficial soils overlying the bedrock at the Site appear to be relatively thin, particularly on the southeastern and southeast to east-central portion of the Site where bedrock outcrops are located. Thicker soils, potentially due in part to fill used during the construction of the

Site, were encountered on the western and northern portions of the Site. This is based on the geology encountered in borings performed by Cushing & Jammallo and a review of the soil borings performed by ATC. Those borings that encountered a greater soils thickness were ATC-3, located on the western portion of the Site, and CJ-4S, located on the northeast portion of the Site. ATC-3 encountered fine to coarse sand to a depth of 11 feet below grade and black sandy silt with some peat from 11 feet to its termination at approximately 19 feet. The upper fine to coarse sand in this boring may be associated with fill used during Site construction. CJ-4S encountered fine sand below fill to approximately 7 feet below grade, grading to fine to medium sand with gravel to 13 feet below grade. Fine sand and silt were present from approximately 13 feet to 22.5 feet below grade at which depth till was encountered.

7.1.2 Bedrock Geology

According to Sundeen (1971), the bedrock geology underlying the Site is mapped as the Eliot Formation, a metasedimentary unit of the Merrimack Group of Silurian age. The Eliot Formation is described as "primarily purplish-brown, medium to fine-grained schists composed of quartz, biotite, chlorite, oligoclase, and actinolite. Minor amounts of light greenish-gray lenses of medium to fine-grained calc-silicate rock are composed of quartz, actinolite, oligoclase-andesine, calcite and sphene. Garnet and diopside are indicator minerals present in schists and calc-silicate rocks in the garnet zone". No major structural features such as faults were identified by Sundeen (1971) to be located at or within the immediate vicinity of the Site.

Cushing & Jammallo utilized a Brunton compass to measure the orientation (strike and dip) of some joints/fractures observed within the bedrock outcrops located south of the Operations Building and the Warehouse. Measurements obtained and the general locations of the joints/fractures are as follows. No attempt was made to determine joint/fracture density.

Strike and Dip of Joint/Fracture	General Location of Measurement and Bedrock Outcrop
N38°W-65°SW	At crest of hill, west of southern portion of Operations Building
N35°W-74°SW	At crest of hill, west of southern portion of Operations Building
N45°W-90°	South of Operations Building
N48° W-90°	South of Operations Building
N45°E-73°NW	South of Operations Building
N45°E-90°	South of Operations Building
N42°E-90°	South of Operations Building
N65°W-85°NE	South of Warehouse
N68°W-85°NE	South of Warehouse
N48°W-85°NE	South of Warehouse
N65°W-83°NE	South of Warehouse
N65°W-86NE	South of Warehouse

As described by Sundeen (1971), the most common joint set in the metasedimentary rocks of this area is nearly vertical and strikes normal to the regional foliation. Sundeen presents the regional foliation as striking or trending approximately 45° to the northeast. The inclination (dip) and trend (strike) of the majority of the of the joints presented above are similar to Sundeen's description, i.e., they are either vertical or relatively close to vertical (73° to 86°) in inclination and the strike (or trend) of the joints is northwest or approximately normal to the northeast trend of the foliation.

Depths to bedrock vary across the Site. Shallower depths to bedrock exist in the eastern and southeastern-central portion of the Site while greater depths to bedrock exist at the western and northern portions of the Site. For example, bedrock was encountered at a depth of approximately 4 feet below grade in CJ-1; approximately 7 feet below grade in CJ-2; approximately 10 feet below grade in CJ-3; and approximately 7.5 feet below grade in ATC-2. However, bedrock was encountered at greater depths at CJ-4S (approximately 22.5 feet below grade) and bedrock was not encountered in ATC-3 at a depth of approximately 19 feet below grade.

7.2 Groundwater Elevations and Estimated Direction of Groundwater Flow

The location and elevations of monitoring wells CJ-1, CJ-2, CJ-3, CJ-4S,and CJ-4D, installed as part of this Site Investigation, were surveyed for Cushing & Jammallo by James M. Lavelle Associates (Lavelle), Licensed Land Surveyor of Hampstead, New Hampshire. The location and elevations of previously existing monitoring wells ATC-2, ATC-4-1, and ATC-4-2 were also surveyed by Lavelle. The National Geodetic Vertical Datum (NGVD) of 1929 was used for the vertical datum. For each of the monitoring wells, the elevations of the rim of the PVC well pipe and rim of the metal guard pipe were surveyed. Figure 2 presents the surveyed location of monitoring wells and the supply wells. The measuring point elevations (top of PVC) provided by are included in Table 2.

Cushing & Jammallo measured the depth to water in the four monitoring wells on June 14, 2000 and July 20, 2000. To determine relative groundwater elevations for each monitoring well, the depth to water measurements were subtracted from the surveyed elevations. Refer to Table 2 for the recorded depths to water, and surveyed measuring point and calculated groundwater elevations. Note that measuring point elevations (top of PVC well pipe) are not provided for monitoring wells CJ-4S and CJ-4D on June 14, 2000. This is due to the fact that the PVC riser pipes in these well were raised by JJA during grading and paving operations between the time the wells were installed and the July water level gauging date. Therefore, groundwater elevations for these wells for the June 2000 water levels would not be accurate.

Presently, four monitoring wells (ATC-3, ATC-4-1, ATC-4-2, and CJ-4S) are completed in the saturated overburden soils. Five monitoring wells (ATC-2, CJ-1, CJ-2, CJ-3, and CJ-4D) are completed in bedrock with the screened portion of the PVC pipe located within the bedrock. These bedrock wells were completed with a seal that extends from above the screened PVC pipe section to above the soil/bedrock interface.

The complete set of groundwater elevations for all existing monitoring wells, based on depths to groundwater measured on July 20, 2000, were reviewed to evaluate flow patterns in both the overburden soils and the bedrock. Figure 4 presents the groundwater contours in the overburden materials and reveals that groundwater flow is westerly. The groundwater gradient in the overburden materials is approximately 0.025 ft./ft. Figure 5 presents the groundwater contours in the upper bedrock system. These contours indicate that groundwater flow is radial, with the groundwater elevation high point located in the vicinity of monitoring well CJ-2. The groundwater high appears to coincide with the bedrock-controlled topographic high at the Site that is located in the vicinity of this well. The principal two directions of groundwater flow in this area appear to be to the northeast and the southwest. The groundwater gradient in both the northeast and the southwest directions is approximately 0.09 ft./ft. This gradient is much steeper than that in the overburden materials. Although the principal groundwater transport in the bedrock system is likely along fractures/joints, etc., the groundwater contours developed for the upper bedrock system do not appear to be suggest fracture-directed flow.

It is likely that the overburden and bedrock groundwater contours and flow patterns presented herein may vary due to various hydraulic influences. For instance, bedrock Supply Well 1 and Supply Well 2 pump on a regular, as-needed basis. Bedrock Supply Well 1 is used intermittently for irrigation purposes. Although the radius or zone of influence of these bedrock wells is presently unknown, the potential exists for these wells, when pumping, to draw groundwater to them that otherwise would not be influenced under static or non-pumping conditions. However, the bedrock groundwater contours do not show groundwater "sinks" indicative of pumping centers. Further, it is not presently known as to whether there is an hydraulic connection between the overburden and bedrock groundwater systems.

8.0 CONCEPTUAL MODEL AND RISK CHARACTERIZATION

8.1 Data Analysis

8.1.1 Known and Potential Contamination Sources

8.1.1.1 Releases to the Environment at JJA

According to JJA, there are presently no known or potential sources of oil or hazardous material to the to the subsurface environment that exist at JJA. Further, the only known and documented historical release of oil or hazardous material at JJA occurred on October 16, 1989 when an estimated 15 to 20 gallons of 1,1,1-trichloroethane was released to a storm drain that was located east of the Operations

Building and immediately adjacent to monitoring well ATC-2. The NHDES described the human health/environmental hazards as "minimal due to clean-up" and no further actions were required for this release. This release is further discussed in Sections 3.0 and 4.3.3 herein. With the construction of the addition to the Operations Building in the second quarter of 2000 over this drain, this drain has been abandoned and closed out. As part of the addition to the Operations Building, this drain was filled in with soil and the building addition was constructed over this former drain. This former drain was substituted by a new drain that was constructed exterior to the new building addition. The new drain was tied into the former subsurface drainage piping.

<u>8.1.1.2 Releases to the Environment at Nearby Properties</u>

The closest commercial/industrial properties to the Site are Alliant Specialty Metals and Land & Sea. Alliant Specialty Metals is located at 135B Route 111, Hampstead and abuts JJA to the east. Land & Sea is located at 138 Route 111, and is located two properties (or approximately 500 ft.) east of JJA.

As described in Section 3.0 of this document, a release of "...approximately 100 gallons of diesel fuel from a leaking semi tractor saddle tank in June 1987" occurred at the loading dock of the building located on the easterly abutting property to JJA. The spill reportedly was "...mostly contained in the paved loading dock area" and "...no subsurface areas were affected..."

Alliant Metals is listed on the NHDES Site Remediation and Groundwater Hazard Inventory "Listing of All Initial Response Oil Spill Projects" for incident dates between January 1, 1995 and August 2, 2000 as having a spill of 100 gallons of No. 2 fuel oil on October 25, 1999. See Section 4.3.1 of Site Investigation Report for further information.

Land & Sea is documented as having a release of MTBE from a 1,000-gallon UST that was removed on September 11, 1996. This tank was reportedly located adjacent to the eastern exterior of the Land & Sea building and, upon removal, "...appeared to be in good condition, with no evidence of pitting, holes, or leaks associated with the UST or piping." However, there was "...visual and olfactory evidence of a release…during the removal activities, near the east wall of the excavation…" Upon removal of the UST, soil samples were collected from the sidewalls and bottom of the excavation and screened with a flame ionization detector (FID) for the presence of volatile organic compounds VOCs. The total VOC concentrations at depths of four to six feet ranged from "…below the detectable limit of 0.1 part per million (ppm) to 45 ppm.", with the greatest concentration encountered from a sample from the east wall of the excavation near the vent pipe. Soil samples from the bottom of the excavation and from the east wall were also submitted to a laboratory for analysis of VOCs by EPA Method 505.2. MTBE was detected at a concentration of 5.9 ppm in the sample collected from the east wall of the excavation. This concentration was in excess of the NHDES Cleanup Guideline of 0.6 ppm. See Section 4.3.1 of Site Investigation Report for further information.

8.1.3 Data Trends

8.1.3.1 Extent of Contamination

No contaminated soil was identified as part of the Site Investigation.

From a lateral perspective, groundwater contaminated with VOCs and nitrate in concentrations above AGQS and/or Method 1 GW-1 or GW-2 standards appears to be confined to the eastern portion of the Site as evidenced by the existence of these analytes in Supply Well 1, Supply Well 2, ATC-2, ATC-4-2, CJ-3, CJ-4S, and CJ-4D. No VOCs have been identified to date above laboratory reporting limits in wells ATC-3 (overburden monitoring well), CJ-1 (bedrock monitoring well), CJ-2 (bedrock monitoring well), or Supply Well 3. Each of these wells is located on the westerly portion of the Site.

Vertically, overburden groundwater at ATC-4-2 and CJ-4S is impacted and groundwater in the upper or shallow bedrock system is impacted. The upper or shallow bedrock groundwater system is herein described as approximately the upper 30 feet of bedrock, according to the interpretation of data from monitoring wells. However, the vertical zone of bedrock groundwater contamination may extend deeper if the water supply wells are considered.

8.1.3.2 Occurrence of LNAPL or DNAPL

Light non-aqueous phase liquids (LNAPL), also known as free phase product, are liquids that are lighter than water and may accumulate as a separate phase on top of the water table. Of the contaminants identified in the groundwater to date, several compounds have specific gravities that are less than water, such as benzene, xylenes, and MTBE. No LNAPL was observed in the groundwater at the monitoring wells sampled by Cushing & Jammallo.

The majority of the chemicals (VOCs) that have been identified as existing in the groundwater at the Site are denser (or have a specific gravity greater) than water. While a minor spill or release of one or more of these chemicals which reaches the groundwater would likely result in the chemicals dissolving in the groundwater, a more significant one time release or a release which occurred over a longer period of time may also result in one or more of these chemicals existing in their own phase (known as DNAPL= dense, non aqueous phase liquid). Since they are denser than water, this would mean that they would tend to dive or sink in the groundwater system until they are intercepted by an impermeable barrier. A rule-of-thumb that is used to evaluate the potential presence of a DNAPL is when the chemical concentration of the analyte is detected at less than 10% of its aqueous solubility limit in groundwater. In addition, chemical concentrations greater than 1% of the chemical's solubility limit in water are highly suggestive of a DNAPL presence.

Based on a comparison of the chemicals and associated concentrations identified in the groundwater to date and published solubilities in water (Smith and Dragun, 1984; Feenstra and Cherry, 1988; Stocking, Koenigsberg, and Kavanaugh, 1999), no chemicals have been identified in concentrations that would suggest the presence of a NAPL, either LNAPL or DNAPL.

8.1.3.3 Occurrence of Natural Attenuation

A discussion of the likelihood of natural attenuation of the chemicals identified to date in the groundwater at the Site is provided herein for informational purposes and to serve as a basis for the potential selection of natural attenuation as the sole remedial measure to address the VOC contaminated groundwater at the Site. The NHDES published a final policy in October 1999 to provide guidance for the selection of natural attenuation as a remedial measure "…to restore groundwater contaminated with volatile organic compounds to Env-Ws 1403 Ambient Groundwater Quality Standards". This policy defines the general conditions under which remediation by natural attenuation may be considered as a remedial component for contaminated sites. Remediation by natural attenuation is defined in the policy as "the naturally occurring processes in the environment that act, without human intervention, to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. These processes include biodegradation, dispersion, sorption, volatilization, and/or biological or chemical stabilization or destruction".

The NHDES indicates in the policy that it "encourages the use of monitored remediation by natural attenuation for remediation of dissolved phase contaminated groundwater at sites where:

- No source of VOCs remains;
- It is demonstrated to be protective of human health and the environment and meets other requirements of Env-Ws 1403.09;
- It is demonstrated [that the contamination] presents no additional risk to receptors;
- Evidence of a stable or receding plume exists;
- Biodegradation or other destructive processes are demonstrated to be occurring; and
- Remedial goals will be achieved within a reasonable period of time including reduction of groundwater contaminant concentrations below AGQS". The policy indicates 10 years as the default value for an acceptable, reasonable remediation time, although this time period may be decreased or increased based on available information, subject to NHDES approval.

According to the NHDES, primary and secondary evidence supporting the occurrence of effective natural attenuation includes the following:

Primary Evidence

- Decreasing primary contaminant concentrations, decreasing concentrations of terminal electron receptors (TEAs), and increase in biodegradation byproduct concentration trends over time in individual wells. TEAs are inorganic constituents such as dissolved oxygen, nitrate, and sulfate.

Secondary Evidence

- Evaluation of the rate of natural attenuation, which may be performed with the use of analytical of numerical modeling or graphical methods.

Based on the laboratory testing results to date (essentially two rounds of testing), trends in contaminant concentrations, TEAs and biodegradation byproducts cannot be effectively evaluated. However, it appears that some primary evidence of VOC degradation is occurring based on the occurrence of certain VOCs in the groundwater at the Site. Degradation products of the following chlorinated organic compounds have been identified in groundwater samples collected from the Site.

Primary Chlorinated Compound	Degradation Products Identified to Date
tetrachloroethene:	trichloroethene cis-1,2-dichloroethene vinyl chloride
trichloroethene:	cis-1,2-dichloroethene vinyl chloride
1,1,1-trichloroethane	1,1-dichloroethane 1,1-dichloroethene cis-1,2-dichloroethene vinyl chloride

8.2 Potential Receptors and Exposure Potential

8.2.1 Migration Pathways and Exposure Potential

Potential migration pathways are discussed for the groundwater contamination that has been identified at this Site to date. Migration/exposure pathways for soil, groundwater, surface water, and vapors are discussed along with exposure potential.

- **Soil above the Water Table.** Headspace screening of unsaturated soil collected from borings performed to date did not display detectable readings. Except for relatively low concentrations of toluene, isopropylbenzene, and 4-isopropylene that were reported by ATC in soil from boring ATC-3, laboratory testing of unsaturated soil indicates that that no VOCs were identified by the laboratories above their applicable reporting limits. Therefore, it would appear, based upon the soil boring program that unsaturated soils do not present a migration pathway or offer an exposure potential to VOC contamination.

- **Groundwater.** Groundwater appears to be the principal transport medium for contaminant migration in both the saturated unconsolidated deposits (soil) and underlying bedrock. VOC contamination has been identified in groundwater from each of the overburden wells that have been sampled by ATC and Cushing & Jammallo (ATC-3, ATC-4-2, and CJ-4S). Only one VOC, 1,4-dichlorobenzene, has been identified in well ATC-3. Although a greater number of VOCs have been identified in groundwater from ATC-4-2, which is located south of the septic system for the Operations Building, the greater concentrations of VOCs have been generally identified in CJ-4S, located north of the Operations Building. Groundwater was not encountered in the relatively thin overburden deposits at some portions of the Site such as at CJ-1 and CJ-2. Groundwater does exist within the saturated soils west of the Warehouse (ATC-3), north of the Operations building (CJ-4S), and south of the septic system for the Operations Building (ATC-4-2). Although these areas of saturated soils may not likely be considered part of an aquifer or aquifer material, groundwater transport is via the connected pore spaces between the grains of soil. Groundwater flow in the overburden material is generally westerly.

The greatest number of VOCs and, generally the highest concentrations identified to date (except for trichloroethene, cis-1,2-dichloroethene, and xylenes), exist in the groundwater within the bedrock monitoring wells. Considering that the bedrock is primarily schist, water bearing properties of a crystalline rock and, therefore, the principal migration pathways for groundwater flow are associated with secondary porosity features, i.e., fractures, joints, etc. Groundwater and dissolved VOCs within the groundwater, have a greater migration potential along systems of interconnected fractures/joints.

Groundwater flow in the bedrock system is radial, with the groundwater high point located in the vicinity of monitoring well CJ-2. The groundwater high appears to coincide with the bedrock-controlled topographic high at the Site that is located in the vicinity of this well. The principal two directions of groundwater flow, however, appear to be to the northeast and the southwest.

- **Surface Water.** Two man-made surface water bodies are located on the Site (Figure 2). One is a lined pond that is located adjacent to Supply Well No. 3 and northwest of the Warehouse Building. This pond serves as a backup supply for fire protection. Water is supplied to this pond from Supply Well No. 3. A second pond is located southwest of the Warehouse Building. This pond serves as a detention basin for surface drainage on a portion of the Site. Although not sampled as part of the Site Investigation, these surface water bodies are not anticipated or expected to be impacted by the Site contamination.

The next closest surface water body as shown on the U.S. Geological Survey map (Figure 1) of is Hog Hill Brook located approximately 500 feet south of the Site. This brook flows in a southerly direction. Two ponds are located along the route of the brook in the vicinity of JJA. Hog Hill Pond is located approximately 1,300 feet northeast of JJA and Hodges Mill Pond is located approximately 500 feet southwest of JJA and across Route 111.

No data is presently available to evaluate or determine any hydraulic connection between these surface water bodies and groundwater, i.e., does groundwater discharge to these water bodies or do the water bodies lose water to groundwater.

- **Groundwater to Indoor Air**. To date, no indoor air quality testing has been performed to evaluate potential impacts of VOCs identified in groundwater to indoor air. However, the potential exists for chlorinated VOCs to exist within the indoor air of the Operations Building due to the fact that trichloroethene is stored and used at this location.

Given the relatively volatile nature of the contaminants that have been identified in the groundwater, an initial comparison has been made between the concentrations of VOCs in the groundwater and the applicable standards for groundwater category GW-2. This category, as described in the NHDES "Risk Characterization and Management Policy", has been established by the NHDES to characterize risks associated with exposure to indoor air contamination, the source of which is contaminated groundwater. Category GW-2 is applicable if the concentration of the analyte is in excess of the established standard, the location of the contamination is within 30 feet of an "existing occupied building or structure, and the average depth to groundwater in that area is 15 feet or less".

Tables 11 and 12 reveal that, of the analytes identified to date by the laboratories and for those analytes that have established GW-2 standards, only two analytes have been identified in concentrations above their applicable GW-2 standards. These VOCs are 1,1-dichloroethene and vinyl chloride. The GW-2 standard for 1,1-dichloroethene is 1 ug/l and the GW-2 standard for vinyl chloride is 2 ug/l. Detectable levels of 1,1-dichloroethene ranged from 1.6 ug/l in CJ-4S to 130 ug/l in ATC-2. The only detection of vinyl chloride was in ATC-2 at a concentration of 3.2 ug/l. Well ATC-2 is located beneath the addition to the Operations Building and well CJ-4S is located less than 15 feet north of the Operations Building.

The current water level measurements do not allow for an accurate annual average depth to groundwater or any trends. However, based upon the existing data, the three water level measurements obtained from ATC-2 (relative to ground surface) reveal that the depth to groundwater is greater than 15 feet. The two water level measurements obtained from CJ-4S place the depth of water at slightly less than 15 feet.

- **Subsurface Utility Lines and Other Services.** Although no information is available for the depth to underground utility for electric, water, drains, and propane gas, the lines for these utilities are likely shallow enough that they are above the VOC contaminated groundwater and, thus do not offer the potential for migration pathways. However, the leachfields associated with the subsurface sanitary wastewater disposal systems offer a direct migration pathway for contaminants since they transmit wastes directly to the subsurface environment.

- **Drinking Water Supplies.** Three supply wells are located on Site (Figure 2). According to Mr. Bean, none of the wells is used for drinking water. Supply Well 1 is located immediately east of the operations building and is only used to for landscape irrigation. Supply Well 2 is located directly beneath the floor of the southern enclosed walkway that connects the two buildings. Supply Well 3, the newest of the wells, is located north of the warehouse building. Both Supply Well 2 and 3 supply water to the buildings' sinks and toilets. According to Mr. Bean, water from all three of the wells contains high iron concentrations. Both Supply Well 2 and 3 have systems have treatment systems. The treatment system for Supply Well 2 is located within the western portion of the operations building. The treatment system for Supply Well 3 is located within the northwestern portion of the warehouse building. No treatment system is presently provided for Supply Well 1, since it is used solely for irrigation.

  Both Alliant Specialty Metals and Land & Sea have supply wells. According to JJA, Alliant does not allow water from its supply well to be consumed. Alliant has supplied bottled water to its employees for this purpose in the past. Currently, water for consumptive purposes on the Alliant property is provided to employees as follows: bottled water may be purchased in a vending machine and a water cooler is located in the office space. The water cooler utilizes water supplied from the Alliant well. Well water entering the cooler is treated by passing through an Innowave 270 brand ion exchange, distillation/filtration system. Cushing & Jammallo is presently not aware of the use, if any, of the supply well located at Land & Sea.

  According to the GIS search that Cushing & Jammallo performed at the NHDES of its database on May 15, 2000, a total of 15 public water supplies are located within a 1.0 mile radius of JJA. Of these fifteen public water supplies, seven are located within a 0.5 mile radius of JJA. JJA is not shown to be located within a 0.25 mile radius of any of these public water supply systems. Section 4.3.2 herein provides further information on this matter.

The NHDES GIS database also provided an inventory of private water supply wells in the area. A total of 17 wells are listed as being located within a 1.0 mile radius of JJA. However, all of the listed wells are located greater than 0.5 miles from JJA. Cushing & Jammallo is not aware of whether any or all of these wells are used for consumption purposes. Further, Cushing & Jammallo is not aware of other private water supply wells that may be located closer to JJA. Section 4.3.2 herein provides further information on this matter.

- **Surface Water**. Two man-made surface water bodies are located on the Site. One is a lined pond that is located adjacent to Supply Well No. 3 at the northwestern portion of the Site and serves as a backup supply for fire protection. Water is supplied to this pond from Supply Well No. 3. A second pond is located southwest of the Warehouse Building. This pond serves as a detention basin for surface drainage on a portion of the Site. Although not sampled as part of the Site Investigation, these surface water bodies are not anticipated or expected to be impacted by the Site contamination. The next closest surface water body as shown on the U.S. Geological Survey map (Figure 1) of is Hog Hill Brook located approximately 500 feet south of the Site. This brook flows in a southerly direction. Two ponds are located along the route of the brook in the vicinity of JJA. Hog Hill Pond is located approximately 1,300 feet northeast of JJA and Hodges Mill Pond is located approximately 500 feet southwest of JJA and across Route 111.

- **Residential Dwellings**. The closest known residential dwellings to the Site are located approximately 0.3 miles west along West Road and Island Pond Road (Figure 1).

8.2.2 Preliminary Groundwater Management Zone Boundary

The Groundwater Management Zone is defined by the NHDES in Section 1403.14 of the New Hampshire Code of Administrative Rules Env-Wm 1403, entitled "Groundwater Management and Groundwater Release Detection Permits", as the zone outside of which there is no violation of groundwater quality. The delineation of the zone's boundary is to be supported by hydrogeologic data and shall consider geologic characteristics of a site, the estimated groundwater flow patterns, and contaminant transport and degradation mechanisms. Use of groundwater within the management zone for drinking water is to be restricted by easement or ownership, except where alternate water is made available. If contaminated water wells are located within the management zone, provisions shall be made for an alternative drinking water supply sized to serve all lots based upon their current use. Groundwater extraction within the management zone shall be restricted by easement or ownership if required to implement a remedy.

Based on the criteria for the delineation of the Groundwater Management Zone, the existing data suggests that groundwater contaminated with VOCs and nitrates in both the overburden soils and upper bedrock systems appears to be confined to the eastern portion of the Site. Figure 2 presents a Preliminary Groundwater Management Zone Boundary. This boundary is considered preliminary since it is essentially based on two rounds of groundwater testing, limited points for the determination of groundwater flow patterns, and limited verifiable data in certain areas that does not allow for the downgradient determination of contaminant concentrations less than NHDES standards. It is, however, based upon the following information:

- Concentrations of VOCs and/or nitrates on the Site in excess of the AGQS and/or the Method 1 GW-1 or GW-2 standards exist in the following wells: Supply Well 1, Supply Well 2, ATC-2, ATC-4-2, CJ-3, CJ-4S, and CJ-4D. No VOCs have been identified to date above laboratory reporting limits in wells ATC-3 (overburden monitoring well), CJ-1 (bedrock monitoring well), CJ-2 (bedrock monitoring well), or Supply Well 3. Each of these wells is located on the westerly portion of the Site.

- The spatial distribution of the contaminants in the upper bedrock groundwater system may be due, in part, to the northwest-southeast trending groundwater divide that directs groundwater flow on the eastern portion of the Site in a northeasterly direction and/or the pumping influence of the supply wells. The groundwater divide may be acting as a natural hydraulic boundary. The pumping of Supply Well 2 and the intermittent pumping of Supply Well 1 may, at times, act to influence contaminant migration toward the wells (including off Site sources). These pumping wells may also be acting as a hydraulic barrier to contaminant migration in the bedrock.

For the overburden groundwater system where groundwater flow is westerly, the lack of VOC contaminated groundwater on the western portion of the Site may be due to a number of factors: no overburden groundwater sampling points are located west of impacted wells CJ-4S or ATC-4-2 except for ATC-3; groundwater transport in the overburden soils is not continuous across the Site because the relatively shallow soils overlying the bedrock are not saturated, or groundwater in this area is simply not impacted by VOCs.

- Contaminant transport in both the overburden and bedrock groundwater appears to be in the dissolved phase. No NAPL or DNAPL was observed. Further, the concentration of the VOCs identified to date do not suggest the presence of DNAPL (refer to Section 8.1.3.2 herein).

- It appears that some primary evidence of VOC degradation is occurring based on the occurrence of certain VOCs in the groundwater at the Site. One or more degradation products of tetrachloroethene, 1,1,1-trichloroethane, and trichloroethene have been identified in groundwater samples collected from the Site.

9.0 CONCLUSIONS, OPINIONS, AND RECOMMENDATIONS

Cushing & Jammallo has performed a Site Investigation in general conformance with Section 1403.07 of the New Hampshire Code of Administrative Rules Env-Wm 1403, entitled "Groundwater Management and Groundwater Release Detection Permits" (most recently published version dated February 24, 1999) and a Scope of Work for Site Investigation activities, dated March 29, 2000, which was submitted to the NHDES by JJA and subsequently approved by the NHDES for implementation. The Site Investigation was also based on discussions with JJA; results of a meeting with the NHDES on March 9, 2000; Cushing & Jammallo's proposal to JJA dated March 29, 2000; and the results of report prepared for JJA by ATC Associates Inc, entitled "Limited Environmental Site Assessment", dated December 17, 1999.

The principal objectives of the Site Investigation were to assess overburden and bedrock groundwater quality with field activities related to the installation of groundwater monitoring wells and the sampling and testing of groundwater; evaluate the direction of groundwater flow;

identify potential contamination sources, migration pathways, and receptors; and provide recommendations, as appropriate. These objectives were accomplished by completing the Scope of Work for the Site Investigation, as submitted to the NHDES, which is presented in Appendix B. Cushing & Jammallo presents the following conclusions and recommendations based on the findings of this Site Investigation.

9.1 Conclusions

1. *Surficial and Bedrock Geology*

- Overburden soils at the Site overlying the bedrock appear to be relatively thin, particularly on the southeastern (10 feet) and southeast to east-central (7.5 feet) portion of the Site where bedrock outcrops are located. Thicker soils (19 to 22.5 feet), potentially due in part to fill used during the construction of the Site, were encountered on the western and northern portions of the Site.

- Several bedrock outcrops appear on the Site. Bedrock at and beneath the Site is described by Sundeen (1971) as medium to fine-grained schist of the Eliot Formation. No major structural features such as faults have been identified at or within the immediate vicinity of the Site.

2. *Chemical Exceedences of NHDES Standards in Groundwater*

VOCs and inorganic parameters have been identified by the laboratory in the overburden and bedrock groundwater systems. Those VOCs and inorganic parameters identified in concentrations in excess of NHDES standards are as follows:

Overburden Groundwater

- The concentration of trichloroethene in overburden well CJ-4S (7.1 ug/l and 16.8 ug/l) is in excess of the AGQS and the Method 1 groundwater standard for category NH GW-1 of 5 ug/l

- The concentration of nitrate-nitrogen in overburden monitoring well ATC-4-2 (50 mg/l and 66.1 mg/l) is in excess of the AGQS/Method 1 groundwater standard for category NH GW-1 of 10 mg/l.

Bedrock Groundwater

- Six VOCs were reported in ATC-2 in concentrations equal to or greater than NHDES standards. Two VOCs, 1,1-dichloroethene and vinyl chloride, had concentrations in excess of both the AGQS/Method 1 groundwater standard for category NH GW-1 and the Method 1 groundwater standard for category NH GW-2. The concentrations of 1,1-dichloroethane, 1,1,1-trichloroethane, trichloroethene, and tetrachloroethene were reported in excess of the AGQS/Method 1 groundwater standard for category NH GW-1. Monitoring well CJ-4D had one VOC, trichloroethene, in a concentration greater than the AGQS/Method 1 groundwater standard for category NH GW-1.

- The concentration of two compounds in Supply Well 1 exceeded NHDES standards. 1,1 Dichloroethene exceeded the AGQS of 7 ug/l and the Method 1 groundwater standards for categories NH GW-1 of 7 ug/l and NH GW-2 of 1 ug/l; MTBE exceeded the AGQS and the Method 1 groundwater standard for category NH GW-1 of 13 ug/l.

- The concentration of two compounds in Supply Well 2 exceeded New Hampshire standards. 1,1 Dichloroethene exceeded the AGQS of 7 ug/l and the Method 1 groundwater standards for categories NH GW-1 of 7 ug/l and NH GW-2 of 1 ug/l; MTBE exceeded the AGQS and the Method 1 groundwater standard for category NH GW-1 of 13 ug/l.

- The concentration of nitrate-nitrogen in bedrock monitoring wells CJ-2 (11 mg/l) and CJ-3 (42 mg/l, 43 mg/l, and 66.1 mg/l) is in excess of the AGQS/Method 1 groundwater standard for category NH GW-1 of 10 mg/l.

3. *Groundwater Flow, Occurrence of Contaminants in Groundwater, and Contaminant Migration*

- Groundwater flow in the overburden soils is in a westerly direction beneath the Site. Radial groundwater flow occurs in the upper bedrock system. From an elevation perspective, a bedrock groundwater high or divide appears to be located in the vicinity of monitoring well CJ-2, just south of the area between the two Site buildings. This hydraulic condition essentially directs groundwater flow in all directions from this area. However, it would appear that the two principal flow directions in the upper bedrock system beneath the Site are to the northeast and southwest, with secondary flow to the northwest and southeast.

  Although the principal groundwater transport in the bedrock system is likely along fractures/joints, etc., the groundwater contours developed for the upper bedrock system do not appear to suggest fracture-directed flow.

  It is likely that the overburden and bedrock groundwater contours and flow patterns presented herein may vary due to various hydraulic influences. For instance, bedrock Supply Well 1 and Supply Well 2 pump on a regular, as-needed basis. Bedrock Supply Well 1 is used intermittently for irrigation purposes. Although the radius or zone of influence of these bedrock wells is presently unknown, the potential exists for these wells, when pumping, to draw groundwater to them that otherwise would not be influenced under static or non-pumping conditions. However, the bedrock groundwater contours do not show groundwater "sinks" indicative of pumping centers. Further, it is not presently known as to whether there is a hydraulic connection between the overburden and bedrock groundwater systems.

- There appears to be a downward hydraulic gradient on the easterly portion of the Site. A review of the groundwater elevations from proximate overburden and bedrock monitoring wells (e.g., overburden well CJ-4S and bedrock well CJ-4D; and overburden well ATC-4-2 and bedrock well CJ-3) reveals that for both sets of wells, the groundwater elevation in the overburden well is higher than the groundwater elevation in the bedrock well, indicating vertical downward flow in these areas. The downward hydraulic gradient in the vicinity of wells ATC-4-2 and CJ-3 may be associated with the adjacent septic system leachfield that likely provides for a continual hydraulic head from the discharge of liquid sanitary wastes.

- From a spatial perspective and based on the present location of monitoring and supplies wells at the Site, VOC contaminated groundwater in both the overburden soils and upper bedrock system appears to be confined to the eastern portion of the Site. No VOCs have been identified to date above laboratory reporting limits in wells ATC-3 (overburden monitoring well), CJ-1 (bedrock monitoring well), CJ-2 (bedrock monitoring well), or Supply Well 3. Each of these wells is located on the westerly portion of the Site. For the upper bedrock groundwater system, this may be due in part, to the northwest-southeast trending groundwater divide that directs groundwater flow on the eastern portion of the Site in a northeasterly direction. For the overburden groundwater system, this may simply be due to the fact that no overburden groundwater sampling points are located west of impacted wells CJ-4S or ATC-4-2 except for ATC-3; or it may be such that overburden groundwater does not exist in some areas do to the relatively shallow bedrock surface.

- The occurrence of MTBE in the supply well at Land & Sea and MTBE and chlorinated VOCs in supply wells at Alliant Metals and JJA dates back to testing performed in 1997. A chlorinated VOC (1,1-dichloroethene) was also detected in the Land & Sea supply well in April 1998.

- Pumping of the bedrock supply wells at the Site may likely be spatially redistributing contaminants in the groundwater at the Site and drawing contaminated groundwater to the Site from off-Site areas. In particular, MTBE is the chemical that appears to have the greatest likelihood of an off-Site source (see discussion below as to the potential source of MTBE).

Further, it would appear that VOCs may be redistributed in the groundwater due to discharge of water pumped from the supply wells to the septic systems. This activity may contribute to the occurrence of the VOCs reported in monitoring wells ATC-4-2 and CJ-3.

- The occurrence and transport of VOCs in the overburden and bedrock groundwater systems appears to be in the dissolved state based upon concentrations identified to date and their solubility in water. Chlorinated VOCs that have been identified in the groundwater are typically a concern because these chemicals have densities (or specific gravities) greater than water and can exist in their own phase under certain conditions. While a minor release of one or more of these types of chemicals to the groundwater would likely result in the chemicals dissolving in the groundwater, a more significant one-time release or a release that occurred over a longer period of time may also result in one or more of these chemicals existing in a separate phase, known as DNAPL, a acronym which stands for dense, non aqueous phase liquid. Since these chemicals are denser than water, they would tend to dive or sink in the groundwater system until they are intercepted by an impermeable barrier. A rule-of-thumb that is used to evaluate the potential presence of a DNAPL is when the chemical concentration is reported at 10 percent of the chemical's aqueous solubility limit in water. In addition, chemical concentrations greater than 1 percent of the chemical's solubility limit in water are suggestive of a DNAPL presence. The concentrations of the various chlorinated VOCs presently reported by the laboratory do not suggest the presence of a DNAPL.

- Based on the criteria for the delineation of the Groundwater Management Zone, the existing data suggests that groundwater contaminated with VOCs and nitrates in both the overburden soils and upper bedrock system appears to be confined to the eastern portion of the Site. The delineation of a Preliminary Groundwater Management Zone Boundary is based upon:

    - Wells identified with concentrations of VOCs and/or nitrates on the Site in excess of the AGQS and/or the Method 1 GW-1 or GW-2 standards exist in wells located on the eastern portion of the Site.

- The spatial distribution of the contaminants in the upper bedrock groundwater system may be due, in part, to the northwest-southeast trending groundwater divide that directs groundwater flow on the eastern portion of the Site in a northeasterly direction and/or the pumping influence of the supply wells. The groundwater divide may be acting as a natural hydraulic boundary. The pumping of Supply Well 2 and the intermittent pumping of Supply Well 1 may, at times, act to influence contaminant migration toward the wells (including off Site sources). These pumping wells may also be acting as a hydraulic barrier to contaminant migration in the bedrock.

  For the overburden groundwater system where groundwater flow is westerly, the lack of VOC contaminated groundwater on the western portion of the Site may be due to a number of factors: no overburden groundwater sampling points are located west of impacted wells CJ-4S or ATC-4-2 except for ATC-3; groundwater transport in the overburden soils is not continuous across the Site because the relatively shallow soils overlying the bedrock are not saturated, or groundwater in this area is simply not impacted by VOCs.

- It appears that some primary evidence of VOC degradation is occurring based on the occurrence of certain VOCs in the groundwater at the Site. One or more degradation products of tetrachloroethene, 1,1,1-trichloroethane, and trichloroethene have been identified in groundwater samples collected from the Site.

4. *Sources of VOC Contamination*

- Presently there does not appear to be an active source or sources of VOC contamination to the subsurface environment at the Site or in the immediately surrounding area. However, based upon the types of VOCs identified in the groundwater to date, the known use of various chemicals at the Site and in the immediately surrounding area, and known and reported releases of chemicals at the Site and in immediate proximity to the Site, Cushing & Jammallo is of the opinion that the potential source or sources of certain VOCs may be as follows:

- A source of 1,1,1-trichloroethane and trichloroethene appears to be associated with JJA based on the following.

  - Use of these chemicals. Although 1,1,1-trichroloethane was used by JJA for the processes in the past, JJA's degreasers presently use tricholoroethene. Trichloroethene is presently stored in one 330-gallon above ground tank (or tote) located on a containment stand within the northerly interior area of the Operations Building along the northerly interior wall. In the recent past, trichloroethene was also stored in a 275-gallon, oval tank (surrounded by a spill containment structure). This tank was also located within the northerly interior area of the Operations Building along its easterly interior wall.

  - Release of 1,1,1-trichloroethane in October 1989. Fifteen to twenty gallons of 1,1,1-trichloroethane were released to a storm drain that was located immediately east of the Operations Building and adjacent to existing monitoring well ATC-2. Although testing results on material in the storm drain did not reveal the presence of 1,1,1-trichloroethane after the drain was cleaned and the NHDES described the human health/environmental hazards associated with this release as "minimal due to clean-up", this drain acted as a potential migration pathway for this chemical to the subsurface environment. This storm drain no longer exists due to the construction of the addition to the Operation Building in 2000. A review of the chlorinated VOCs identified in the groundwater to date reveals that monitoring well ATC-2 contains the greatest concentrations of chlorinated compounds, suggesting that this location was a former source of 1,1,1-trichloroethane to the subsurface environment.

  - Barrels and Drums Observed Exterior on the Northern Portion of the Site. The Town of Hampstead observed "a number of empty barrels to the rear of the property" in June 1987. Some of the barrels were labeled as waste 1,1,1-trichloroethane. In January 1990 approximately 15 drums were observed north of and exterior to the building. The NHDES also observed 31 drums north of the building in 1990 (some